Heart weight, Left Ventricular Wall Thickness, and Interventricular Septum Thickness in Cardiac and Moncardiac Causes of Deaths: A Cross-sectional Postmortem Study in Babylon Province

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Abstract

Background The heart weight and left ventricular (LV) mass reflect on the severity of coronary artery diseases. In clinical practice, it can help physicians decide whether to perform invasive cardiac catheterization to visualize the extent of the coronary block. **Material and methods** this study is a cross sectional postmortem study included 80 cases, for which a full autopsies were performed, and included measurement of heart weight, left ventricle posterior wall thickness, and interventricular septum thickness. The measurement was statistically analyzed and correlated to age sex and cardiovascular diseases. **Results;** the result of this study has revealed a strong positive correlation between age and heart weight; Correlation is significant at the 0.01 level (2-tailed). By using student (t) test, the difference between the means weight of heart in males and females is highly significant: **P < 0.05. P = 0.004.** The same result were obtained for the LVPW thickness and IVS thickness; the difference in mean LVPW thickness and IVS thickness between male and female is highly significant **P < 0.05.** There is a strong positive correlation between heart weight and cardiac diseases as well as the LVPW and IVS thickness and cardiovascular diseases. **Conclusion** there is a highly significant positive correlation between age and sex, on one hand, and interventricular septal thickness, left ventricular posterior wall thickness and heart weight on the other hand, and, therefore, age and sex should be considered in order to assess the significance of these measurements in clinical practice. Cardiovascular diseases such as hypertension and coronary artery disease are associated with increased heart weight and increased left ventricular wall thickness and interventricular septum thickness.

Key Words: Heart Weight, Left Ventricle Wall Thickness, Interventricular Septum Thickness, Cardiac Cause of Death, Noncardiac Causes of Death,

Introduction

The left ventricle forms the bulk of the mass of the heart and it is the main pumping chamber of the heart; it pumps the blood to the systemic circulation through the aorta. It consists of a thick muscular wall and an inlet; via the mitral valve, apical trabecular, and an outlet portion leading to the aortic valve. The ventricular wall is thickest near the cardiac base and thinnest at the apex **(Ho, S. Y., 2009)**. Throughout the ventricular wall, the myocardial bundles have a characteristic arrangement so that the strands change orientation from being oblique in the subepicardium to circumferential in the middle and to longitudinal in the subendocardium, the longitudinal portion being the thinnest. The left ventricular posterior wall thickness at end systole (LVPWs) and end diastole (LVPW) is 0.6-1.1 cm. The normal range is 0.7-2.3 cm. Interventricular septal thickness at end-diastole is between 0.6 and 1.0cm **(Kitzman, D. W., Scholz, et al., 1988, Abdelzaher, M. A. 2024)**. With advancing age, the left ventricle (LV) undergoes structural and functional changes, thereby predisposing for the development of cardiac diseases. One possible mechanism of the ageing heart is a cellular aging **(Sjögren, A. L. 1971)**.

Thickening of the walls of the left ventricle is called hypertrophy of the left ventricle. Uncontrolled high blood pressure is the most common cause of left ventricular hypertrophy. Factors positively associated with increased left ventricular mass are body weight, male sex, and systolic pressure, presence of congestive heart failure, present smoking, hypertension, valvar heart disease, and aortic regurgitation **(Marcomichelakis, J., Withers, R., et al., 1983)**. It has been found, by cardiovascular magnetic resonance study of LV volume, that mass and linear dimensions of left ventricle differ significantly

according to gender and body size. Cardiac function and morphology are known to differ between men and women; women have smaller LV chambers and accordingly lower stroke volumes **(Gardin, J. M., Arnold, A., et al., 1997)**.

At a cellular level, the number of cardiomyocytes is similar between sexes at birth, but aging women have a relatively decline in cardiomyocyte number and mass, with fewer tendencies toward cardiomyocyte hypertrophy and eccentric LV remodeling compared with men. Cardiac remodeling, which are changes in heart function and morphology were found to be associated with the process of aging **(Salton, C. J., Chuang. et al., 2002, Wooten, S. V., Moestl, S., et al., 2021)**. Hypertrophy of the left ventricle, dystrophic changes in aortic valve and impaired diastolic function are age associated **(Bjerring, A. W., Landgraff, H. E., et al., 2018, Redfield, M. M., Jacobsen, S. J., et al., 2005, Finocchiaro, G., Westaby, J., et al., 2024)**.

According to Gray's Anatomy, the heart length, width, and thickness are 12 cm, 8.5 cm, and 6 cm, respectively. In addition, the mean weight of the heart is 280-340g in males and 230-280 g in females, **(Fitzgibbons, T. P.,2023, Kajstura, J., Gurusamy, N., et al., 2010, Mohammadi, S., Hedjazi, A., et al., 2016)**. The left ventricle diameter measured at 20 mm from the base of the heart correlated significantly (albeit moderately) with heart weight, suggesting it can a predictor for cardiac hypertrophy **(Mohammadi, S., Hedjazi, A., et al., 2016, Tanna, J. A., Patel, P. N., et al., 2011, Garland, J., Thompson, M., et al; 2023)**.

The aim of the present study is to make measurements of the heart weight, left ventricle wall thickness, and interventricular septum thickness and find their relations to age gender and various cardiac diseases.

Material and Methods

This study included 80 autopsies (56 male and 24 females) the cases were referred to the Office of Forensic Medicine in Babylon Governorate from various districts. Age range was (13-80 years) and mean age was (37 – std. deviation 14.09). The cases were classified according to age, gender and cause of death. According to the cause of death the cases were divided into two major groups, those who died from cardiac causes and those who died from noncardiac.

A full autopsy for each case was performed by expert forensic pathologist, and all findings were registered in special forma, with special attention to the cardiovascular findings. At the first step, the heart and lungs were dissected and removed en block. The heart was dissected out of the lungs. After three days of fixation in formalin, thickness of the posterior wall of the left ventricle (LVPW) and the thickness of interventricular septum (IVS) were measured directly and cited in cm. The measurements of the posterior wall thickness were taken about 20mm below the base of the heart Figure (1).

The weight of the heart for each case was measured by electronic balance and the results were expressed in grams. The relationships of the LVPW and IVS to the age, gender, and cardiac diseases were studied by using convenient statistical method. Data management and analysis were performed using SPSS 13.0 (SPSS) software. Data are presented as means ±SDs for continuous variables and as percentages for categorical variables. Between-gender comparisons were made by χ^2 statistic, unpaired Student *t* test, and ANOVA, as appropriate.

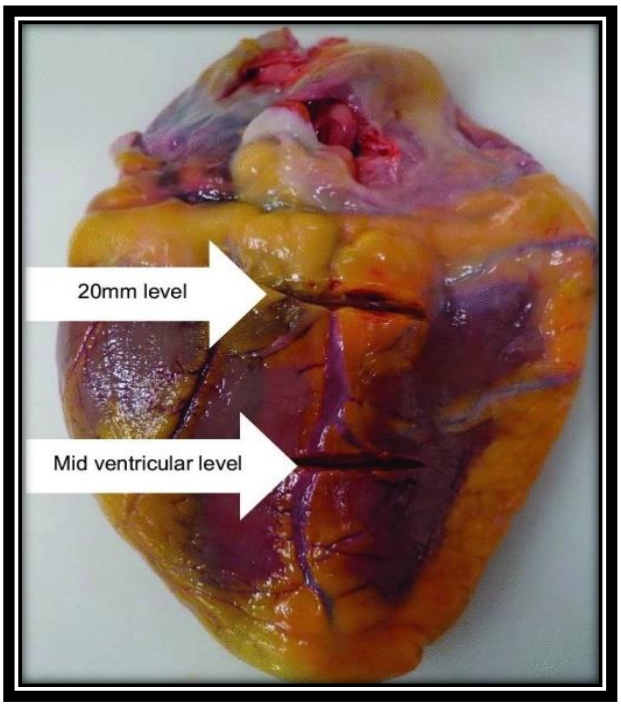

Figure1: Sites on the posterior wall of the left ventricle where measurements were taken.

Results

All collected and analyzed data are tabulated below. Starting with the raw data; Table 1; shows the distribution of cases by age groups and sex.

Cases distribution are seen in Table 2, distribution of cases by mean age and sex. Figure (2), shows the cases distribution by percent value.

Table (3 and 4), reflect the association between the heart weight and the age and the correlation between the weight of heart and the sex, respectively. By using student (t) test, the difference between the two means is highly significant: **P < 0.05. P = 0.004.**

Further, comparison of heart weight between cardiac and noncardiac cases is tabulated in Table (5), and the weight of compression by percent (%), is shown in Figure (3). The correlation relation between age and left ventricular wall thickness and the correlation between age and interventricular wall thickness are shown in Tables (6 and 7) respectively.

Eventually, the Correlation between Sex and LVPW. and IVS thickness and the correlation of LVPW wall thickness and interventricular septum IVS with the cause of death are shown in Tables (8 and 9) respectively. Figure (4), explain the correlation of LVPW Wall Thickness and Interventricular Septum IVS by percent (%).

Table 1: Distribution of cases by age groups and sex

Age group	No. of cases	Male	Female
11 - 20 y	7 (8.75%)	5	2
21 - 30 y	29 (36.25%)	17	12
31 - 40 y	21 (26.25%)	17	4
41 - 50 y	11 (13.75%)	10	1
51 - 60 y	6 (7.5%)	3	3
61 - 70 y	3 (3.75%)	2	1
71 - 80 y	3 (3.75%)	2	1
The total	80 (100%)	56	24

Table 2: Distribution of cases by mean age and sex

Sex	Number	Mean age	Std. Deviation
Male	56	36.3929	14.09794
Female	24	34.3750	16.03749

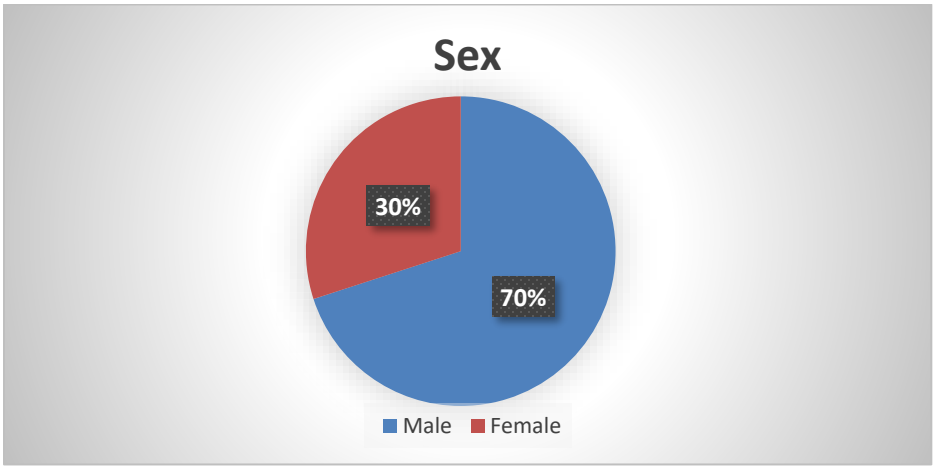

Figure 2: Distribution of cases by percent %

Table 3: Association between the heart weight and the age

Association between heart weight and age		**Age**	**weight of heart**
Age	Pearson Correlation	1	0.467**
	Sig. (2-tailed)		0.000
	N	80	80
****Correlation is significant at the 0.01 level (2-tailed).**			

Table 4: The correlation between the weight of heart and the sex

Sex	N	Mean weight of heart in gm	Std. Deviation	P value (t test)
Male	56	393.2143	135.97269	.00400
Female	24	304.3750	80.20778	

Table 5: Comparison of heart weight between cardiac and noncardiac cases

Group	N	Mean weight of heart in gm	Std. Deviation	P value (t test)
Cardiac	19	518.4211	144.91427	0.00000
Non-Cardiac	61	319.2623	75.80587	

The difference between the two means is highly significant: **P < 0.05; P = 0.00000**

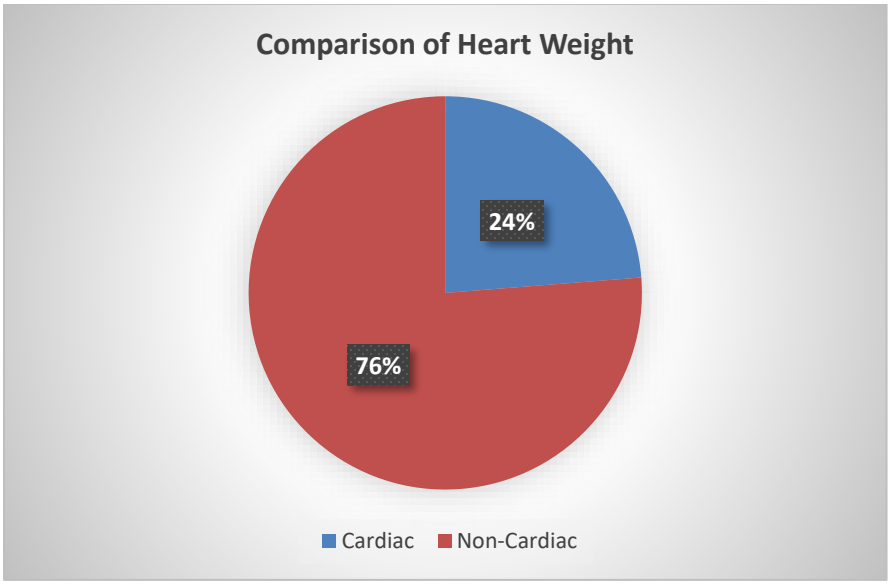

Figure 3: Comparison of heart weight between cardiac and noncardiac cases by percent %

Table 6: Correlation relation between age and left ventricular wall thickness

Correlation relation		Age	LV
Age	Pearson Correlation	1	0.350**
	Sig. (2-tailed)	---	0.001
	N	80	80

**Correlation is significant at the 0.01 level (2-tailed).

Table 7: Correlation between age and interventricular wall thickness

Correlation		Age	IV
Age	Pearson Correlation	1	0.395**
	Sig. (2-tailed)	---	0.000
	N	80	80

**Correlation is highly significant at the 0.01 level (2-tailed).

Table 8: Correlation between Sex and LVPW. and IVS thickness

Heart wall	Sex	No. of cases	Mean thickness in cm	Std. Deviation	P value
L. ventricle Posterior wall thickness (LVPW)	Male	56	1.8732	0.36005	0.02200
	female	24	1.6833	0.25481	
Interventricular thickness	Male	56	1.7929	0.36074	0.00000
	female	24	1.4792	0.23953	

The difference in thickness between male and female is highly significant, **P < 0.05**

Table 9: Correlation of LVPW wall thickness and interventricular septum IVS with the cause of death

Heart wall	Group	N	Mean	Std. Deviation	P value (t test)
L. ventricle posterior wall thickness	Cardiac	19	1.9316	0.35598	0.00100
	non-cardiac	61	1.6443	0.29013	
Interventricular thickness	Cardiac	19	1.9000	0.46428	0.00400
	non-cardiac	61	1.6361	0.29554	

The difference between means thicknesses in both groups is highly significant; **P < 0.05**

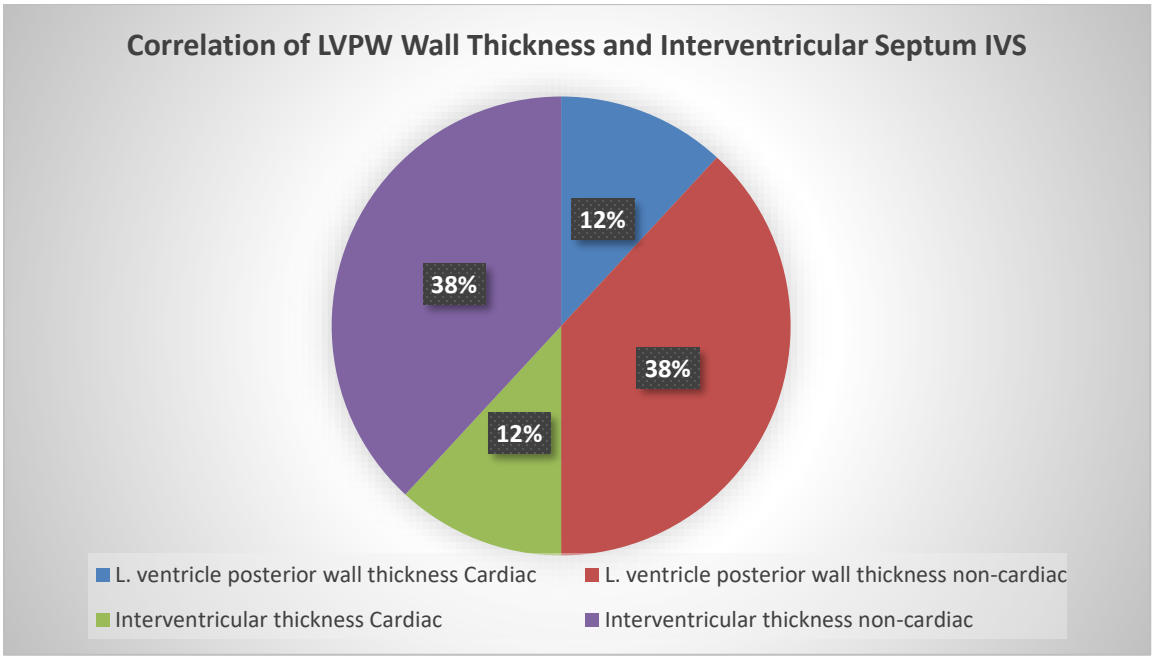

Figure 4: Correlation of LVPW Wall Thickness and Interventricular Septum IVS by percent %

Discussion

The result of the present study shows that the majority of cases have fallen in age group (21-40 years) about 62% (50 cases). Mean weight of the heart was about 393 gm for males and 304 gm for females, statistically the difference between the two means is highly significant P<0.05. This result is in agreement with other studies, it has been reported that females had a significantly lower heart weight (285±55 vs 374±64). Sex was an independent predictor of most measurements. The mean weight of the heart in cases died from cardiac causes was 518.4 gm, and for noncardiac cause was 319.26 gm. The mean LVPW thickness was 1.87 cm (Stander deviation 0.37600) for males and 1.633 cm (std. deviation 0.2548) for females. The mean IVS thickness for males was 1.79 cm and 1.47 cm for females. The mean LVPW thickness in cases died from cardiac causes was 1.93 cm and 1.63 cm for noncardiac causes.

The present study has revealed a strong positive correlation between heart weight and age as well as with sex; Table 3 and 4. In addition there is a statistically significant difference in mean weight between cardiac and noncardiac cases table 5. The results of the present study have also revealed that that there are significant positive correlations between age of the patient and LVPW thickness and IVS thickness, **P< 0.01,** Table 6, 7, and 8. This finding is in agreement with other studies **(Garland, J., Thompson, M., et al., 2023, Marcomichelakis, J., Withers, R., et al., 1983)**. The same thing applies to the effect of sex on the heart weight and LVPW thickness; there is a significant difference between males and females in weight of the heart and left ventricle thickness and IVS, table 5 and Table 2. The effect of sex on morphology of the left ventricle has been reported by many investigators **(al'Absi, M., Devereux, R. B., et al., 2006, Petersen, S. E., Aung, N., et al., 2016, Krumholz, H. M., Larson, M., et al., 1983)**.

It has been reported by Goble *et al*. that LV mass differs by sex, adjusted for weight, and that LV mass sex difference was strongly related to body fat mass. These LV mass differences were attributed to hemodynamic sex difference, where girls have faster heart rates than boys which contributed to lower LV mass, while high systolic blood pressure in boys contributed to higher LV mass **(Goble, M. M., Mosteller, M., et al., 1992)**. It has also been demonstrated that women suffer from coronary microvascular dysfunction, are now a recognized major contributor to the ischaemia with no obstructive coronary disease **(Redfield, M. M., Jacobsen, S. J., et al., 2005, Bairey Merz, C. N., Nelson, et al., 2020, Bairey Merz, C. N., Pepine, C. J., et al., 2017, Ji, H., Kim, A., et al., 2020, Kararigas, G., Dworatzek, E., et al., 2014, Westaby, J. D., Zullo, E., et al., 2023)**. The present study has also demonstrated that there is a strong positive correlation between LVPW thickness and age and sex. tables 6 and 7. There is also a strong positive correlation between the IVS thickness and age and sex tables, 7 and 8.

These results are in agreement with other studies **(Pfaffenberger, S., Bartko, P., et al., 2013).** Aging is associated with physiological changes in the vasculature and heart. With aging, physiological functional capacity of various organs, cardiovascular responsiveness, and autonomic homeostasis go down. Aging starts with birth and accelerates with advancing age **(Pelà, G., Crocamo, A., et al., 2016)**. The alterations that occur during the aging process go unnoticed for a long time until it requires medical attention. Aging is a dominant risk factor for CVDs and predisposes the heart to various adverse structural and functional alterations. A high prevalence of HF is noted in the older population, generally above the age of 65. Many of these changes are the consequence of CVDs. Nevertheless, changes can occur even in the absence of clinical cardiac dysfunction **(Lakatta, E. G., & Levy, D. 2003, Lakatta, E. G. 2001, Weber, K. T., Sun, Y., et al., 1994**).

An age-dependent increase in the prevalence of LVH in healthy individuals has been reported in the Framingham Heart Study and the Baltimore Longitudinal Study on Aging without concomitant CVDs. They have also shown age-dependent decline in diastolic function and relatively preserved systolic function at rest **(Benjamin, E. J., & Levy, D.,1999)**. Chronological age is a contributing factor for the changes in the cardiovascular structure and function. The presence of cardiovascular ailments accelerates the cardiac aging process. The changes observed in HHD and aging are more or less similar in terms of the cellular and molecular mechanisms. In both hypertension and aging, increased oxidative stress is a major source for the activation of signaling molecules. Cardiac aging is a complex process and involves intrinsic and extrinsic factors.

The present study shows that there is a strong positive correlation between cardiovascular diseases and heart weight and left ventricle thickness and interventricular septum thickness, Tables 5 and 9. It has been reported that hypertension and aging are two major risk factors for the

development of cardiac structural and functional abnormalities. Hypertension, or elevated blood pressure will lead to heart failure HF if left untreated. Left ventricular hypertrophy as a result of pressure overload is the most important indicator of congestive HF and sudden death. The pathological changes occurring during hypertensive heart disease are very complex and involve many cellular and molecular alterations. In contrast, the cardiac changes that occur with aging are a slow but life-long process and involve all of the structural components in the heart and vasculature **(Marcus, M. L., Harrison, D. G., et al., 1987)**. However, these structural changes in the cardiovascular system led to alterations in overall cardiac physiology and function. The changes of the myocardium occurring during pathological hypertrophy not only affect the parenchyma but also the stroma, which forms the ECM. The ECM is composed of fibroblasts which secrete collagen along with smaller amounts of elastin, laminin, and fibronectin. The fibrillar collagen provides structural integrity to adjoining myocytes and aids in myocyte contraction that translates into efficient cardiac contraction.

The present study has revealed that there is strong positive correlation between heart weight and left ventricle thickness. Left ventricular hypertrophy (LVH) has been well studied as a consequence of coronary artery disease CAD; however, there has been a gap in studies regarding LVH as a significant risk factor for CAD. Although there has been much debate about why LVH is such an important risk factor, the basic mechanisms that predispose patients with LVH to develop atherosclerosis and consequent CAD are not well understood.

Conclusion

The results of the present study showed that there is a highly significant positive correlation between age and sex, on one hand, and interventricular septal thickness, left ventricular posterior wall thickness and heart weight on the other hand, and, therefore, age and sex should be considered in order to assess the significance of these measurements in clinical practice. Cardiovascular diseases such as hypertension and coronary artery disease are associated with increased heart weight and increased left ventricular wall thickness and interventricular septum thickness.

Conflict of Interest

The authors declare no conflict of interest.

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